Characterizing Potential ‘Bridging Ground’ Conditions Using the Refraction Microtremor (ReMi) Surface Seismic Technique

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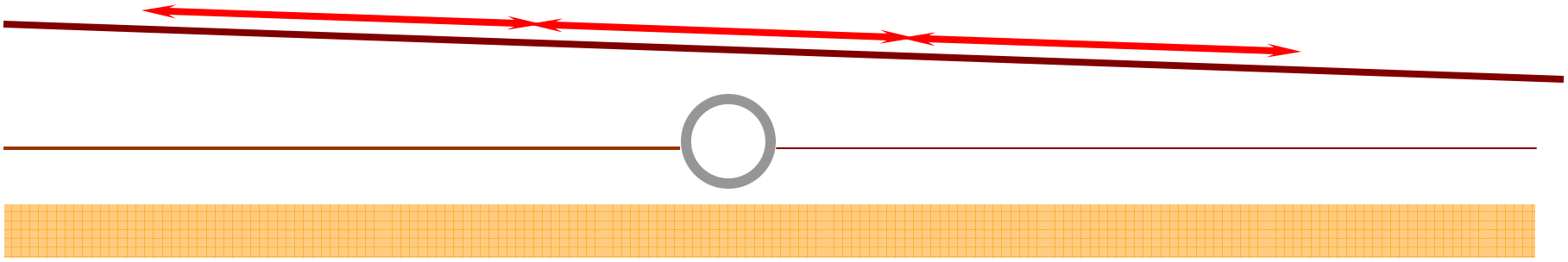
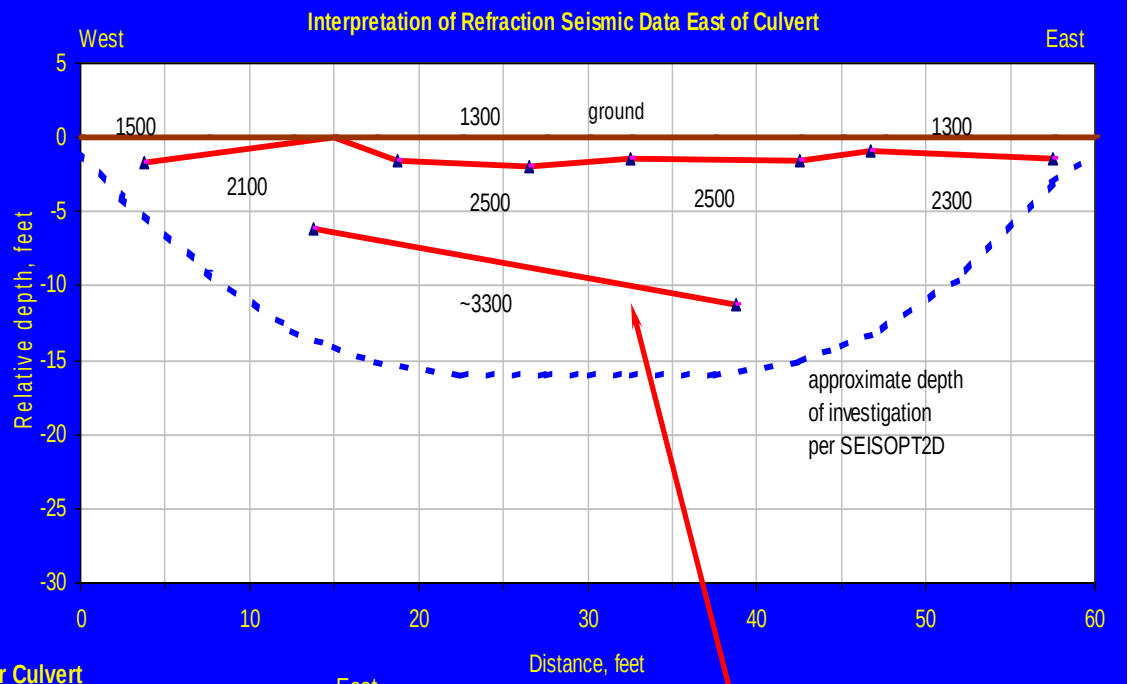
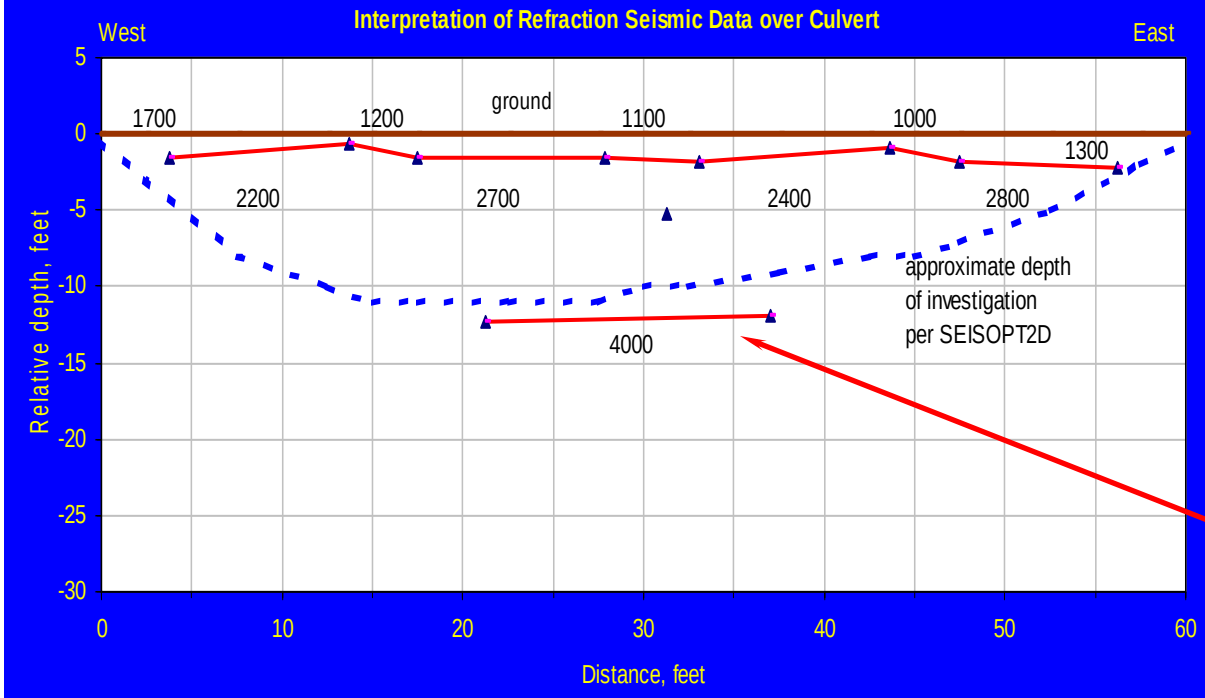
Investigate a known culvert in an embankment (void without cracking)



Standard refraction interpretation did not indicate the presence of the culvert, and included interpretation of an underlying native cemented soil horizon

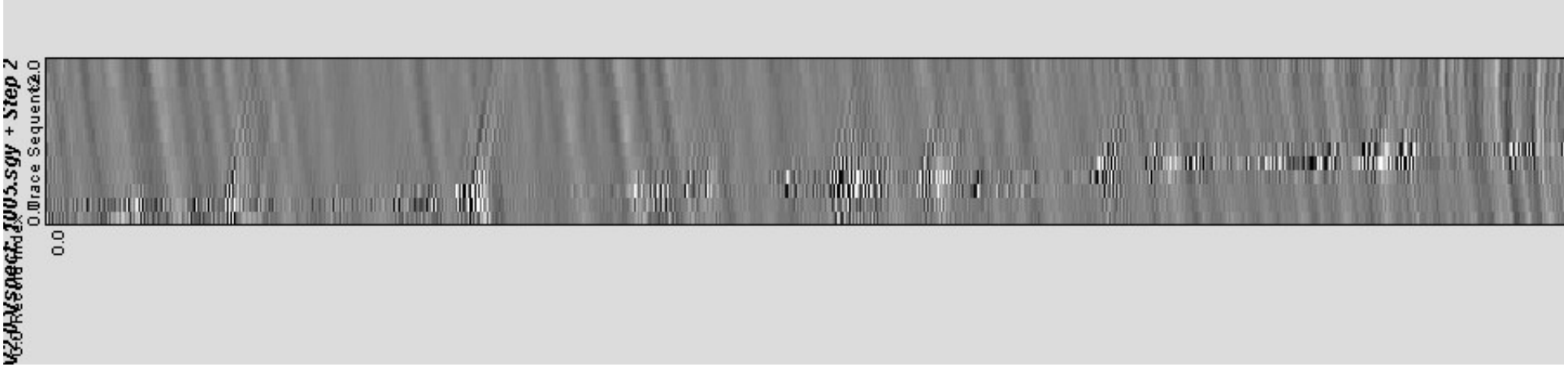




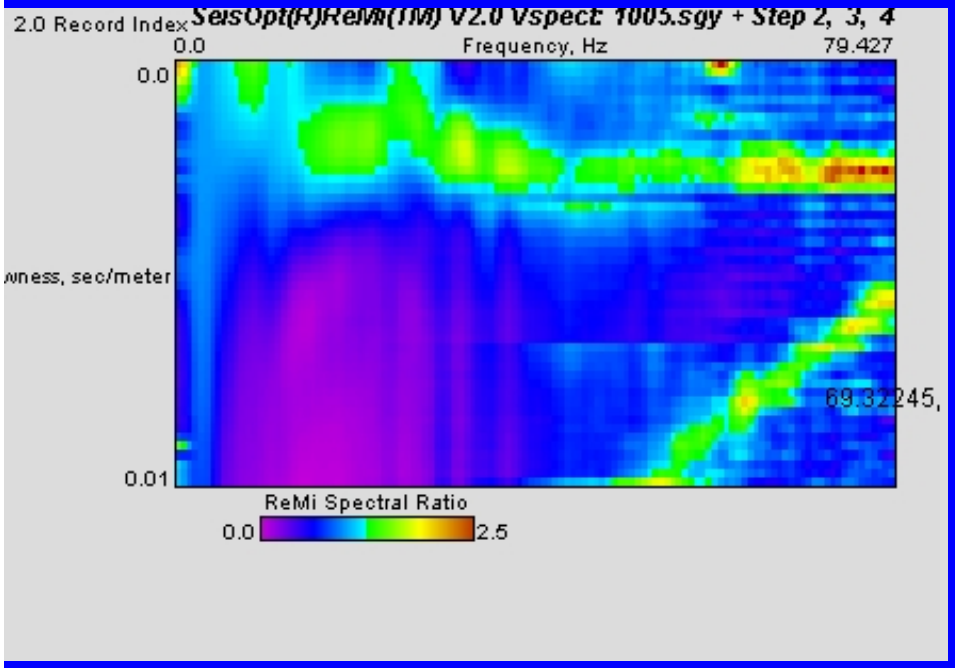
Underlying native cemented soil horizon

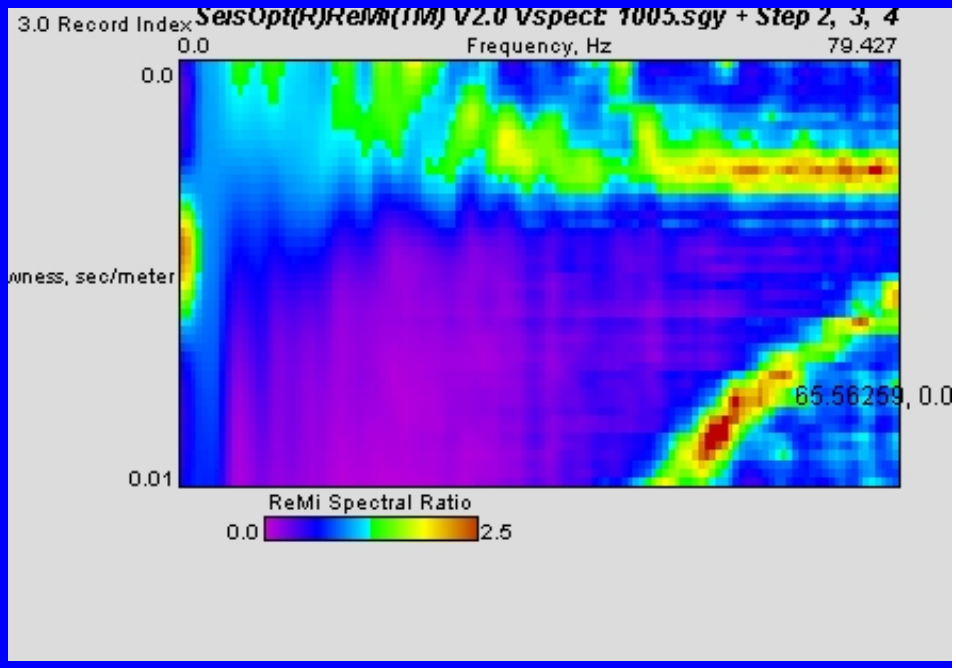
ReMi data is collected using same field setup as standard seismic refraction setup – Instrument sampling intervals are changed

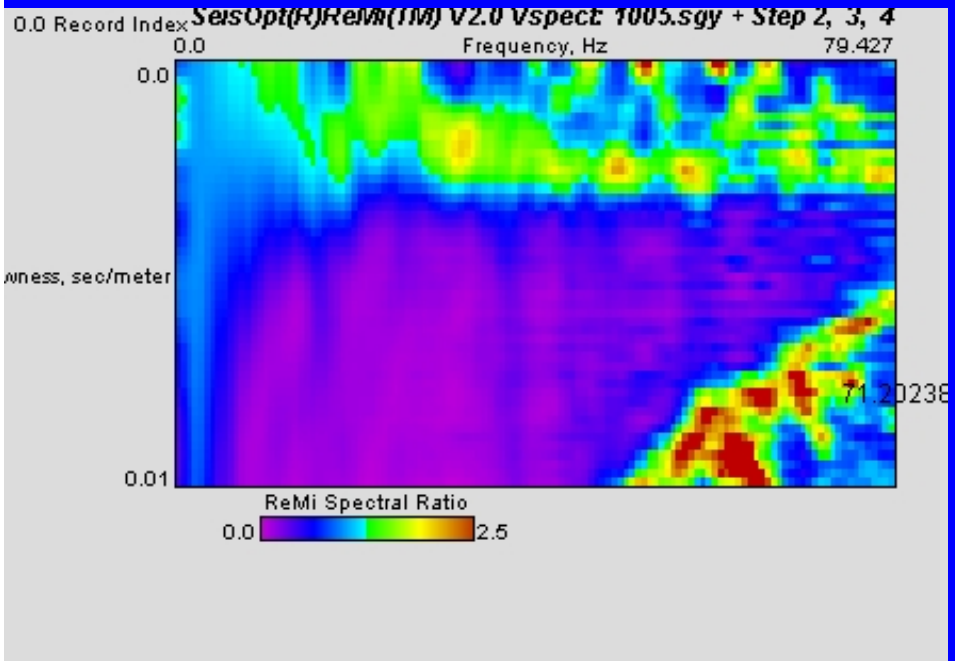
Example ReMi time-history data

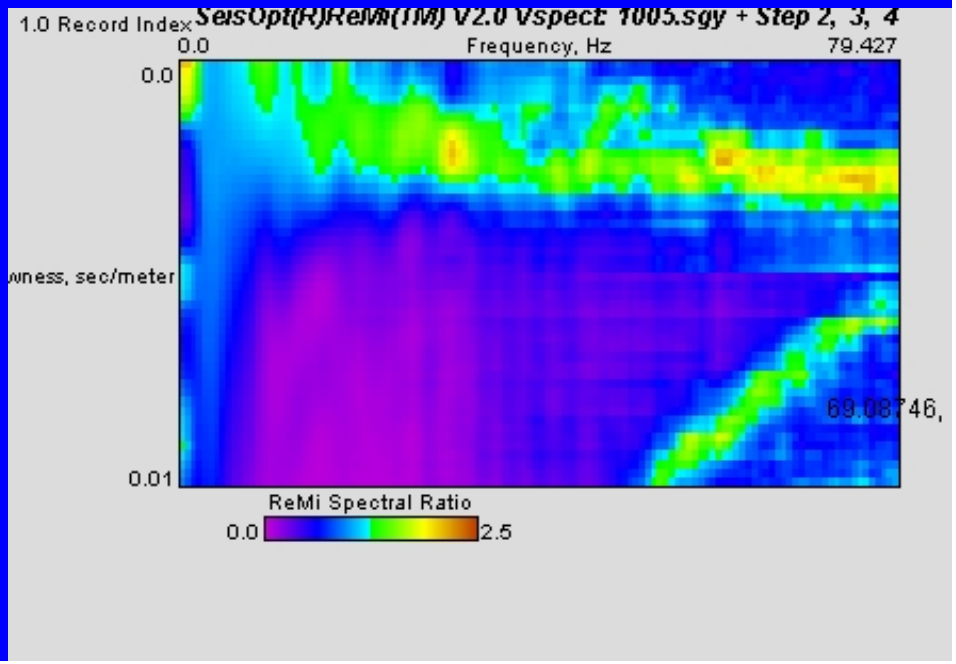


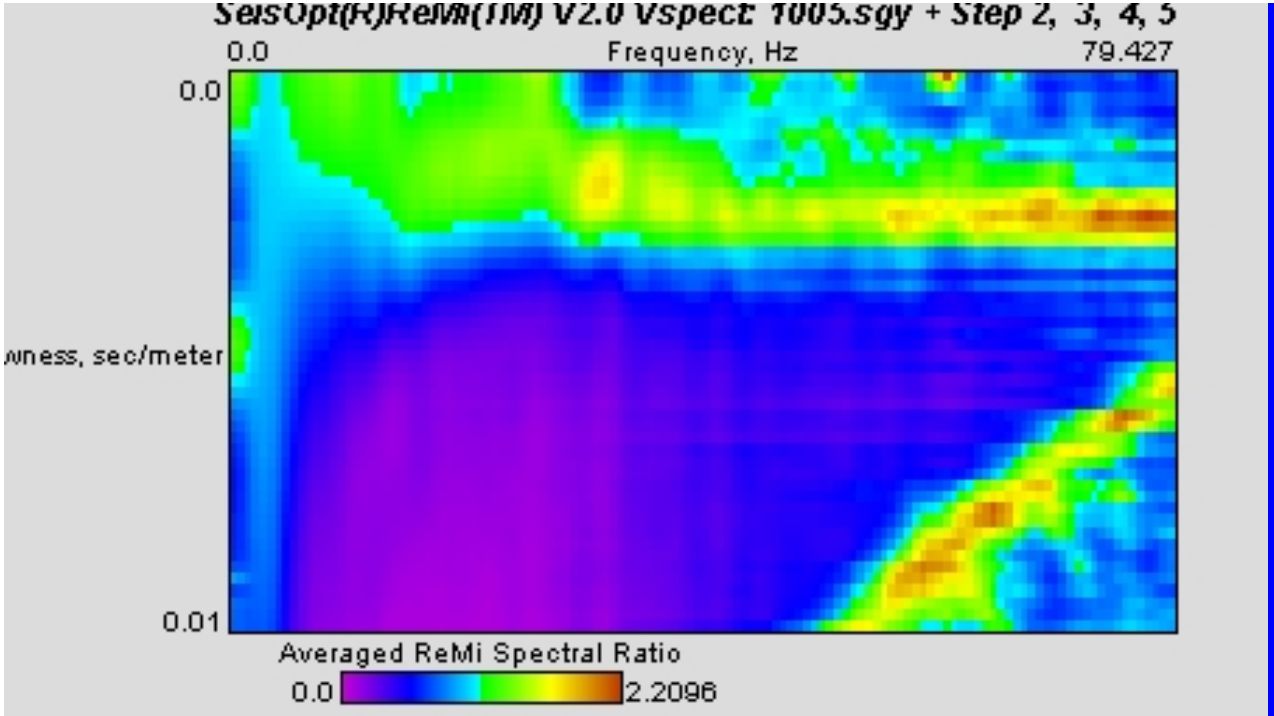
ReMi results for 4 sampling events – person jogging is source





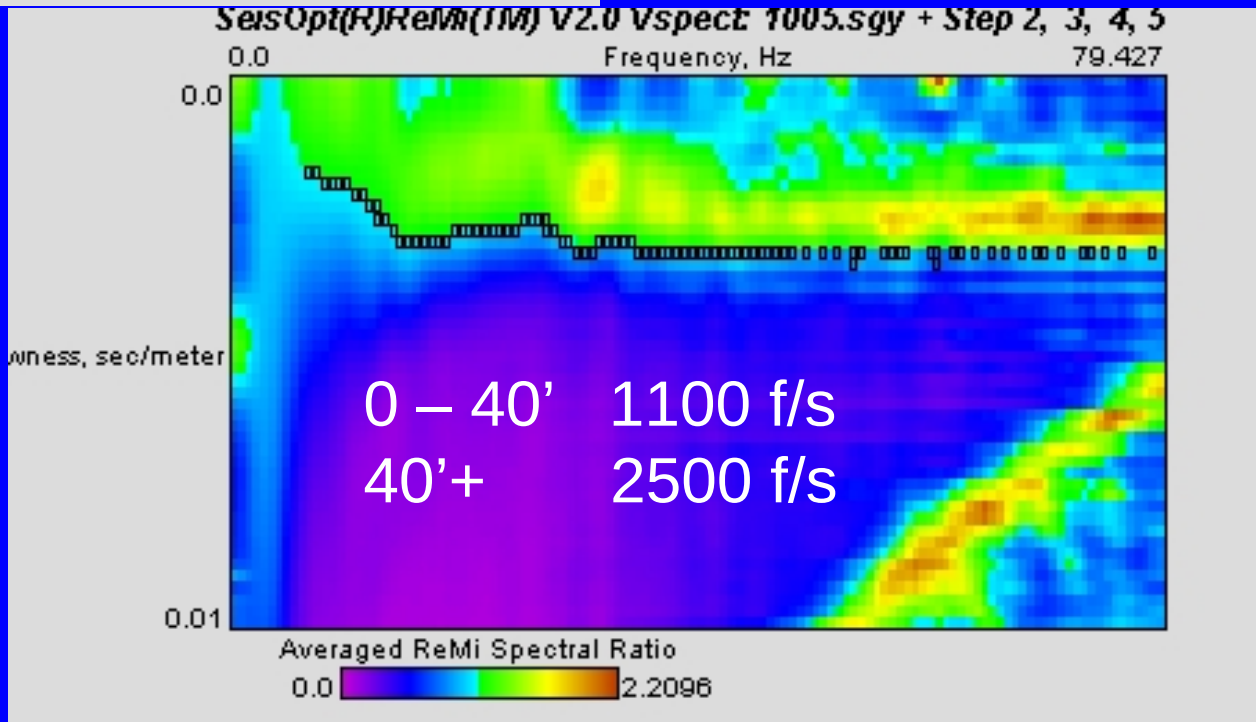


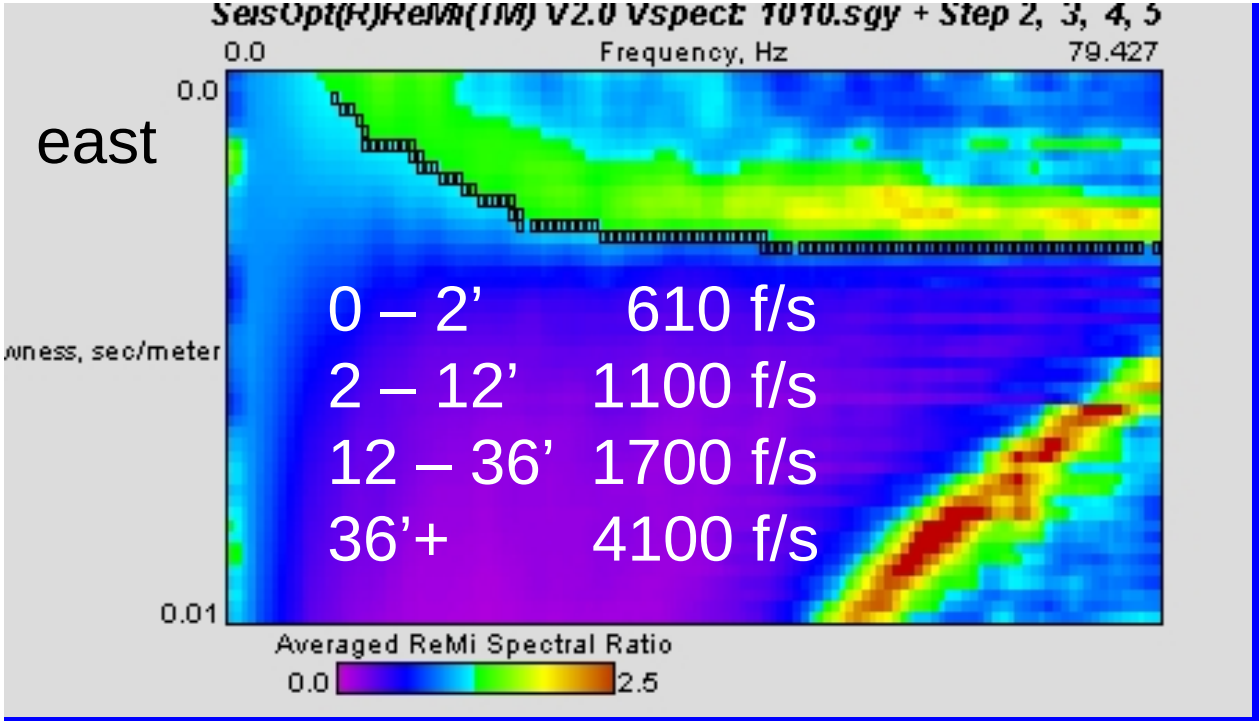




ReMi results combined over culvert

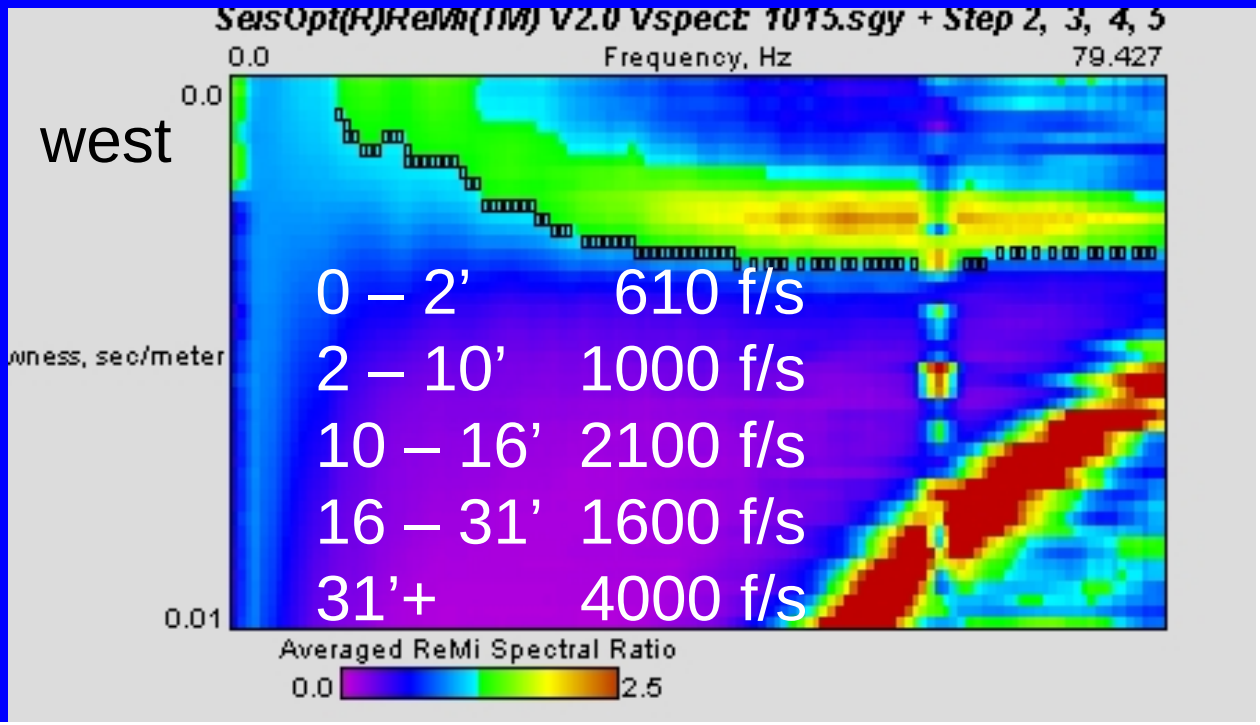
Picking dispersion points from combined results



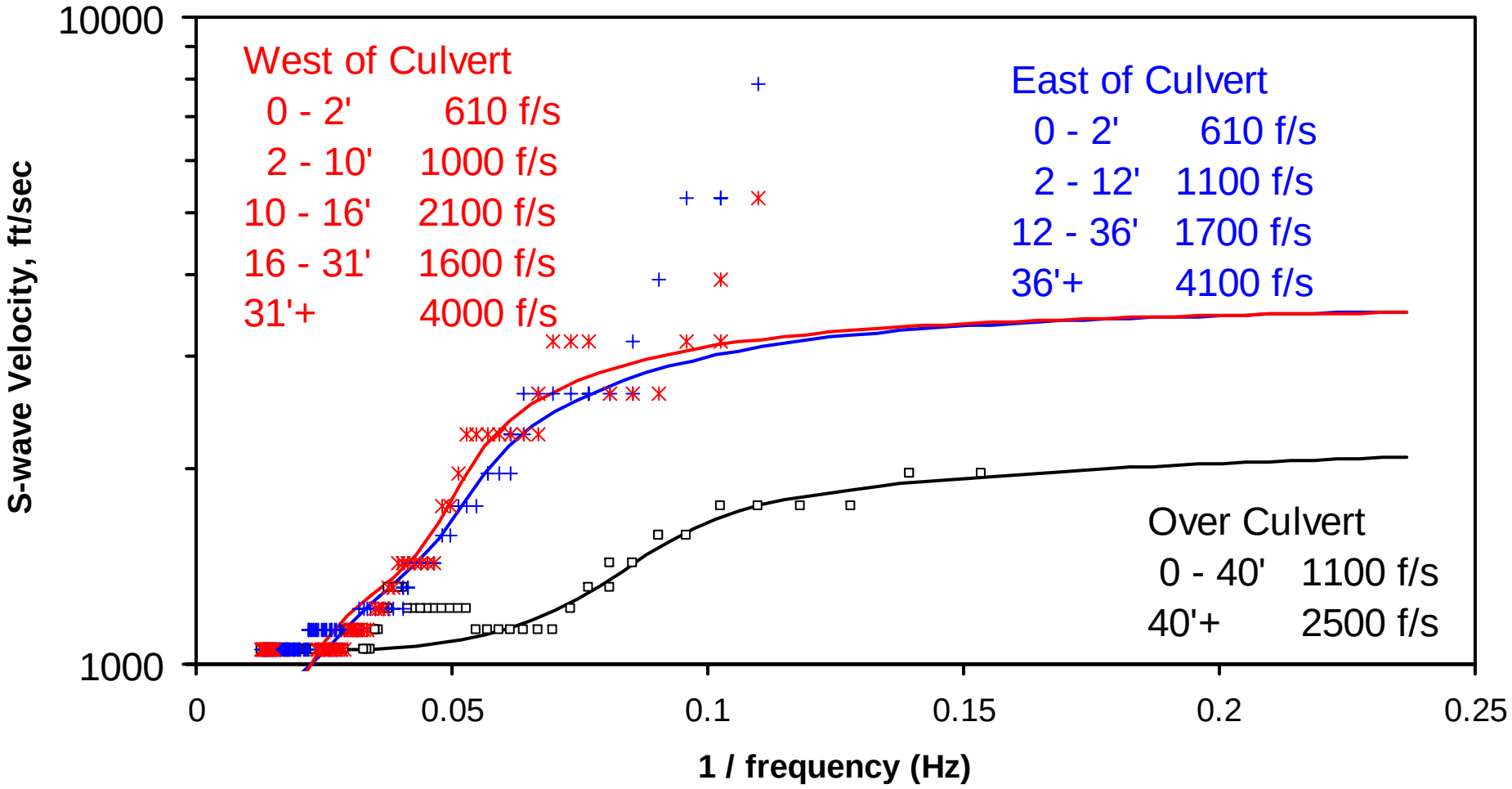


Results and dispersion point trends from ReMi data to east & west of culvert were similar to each other and showed cemented soil horizon

Note: 60 Hz noise signature did significantly interfere with analysis



Dispersion curve interpretations showed that the s-wave profile at the culvert was significantly different from the profiles on either side



Identifying & Locating ‘Connected’ Cracks in Subsurface

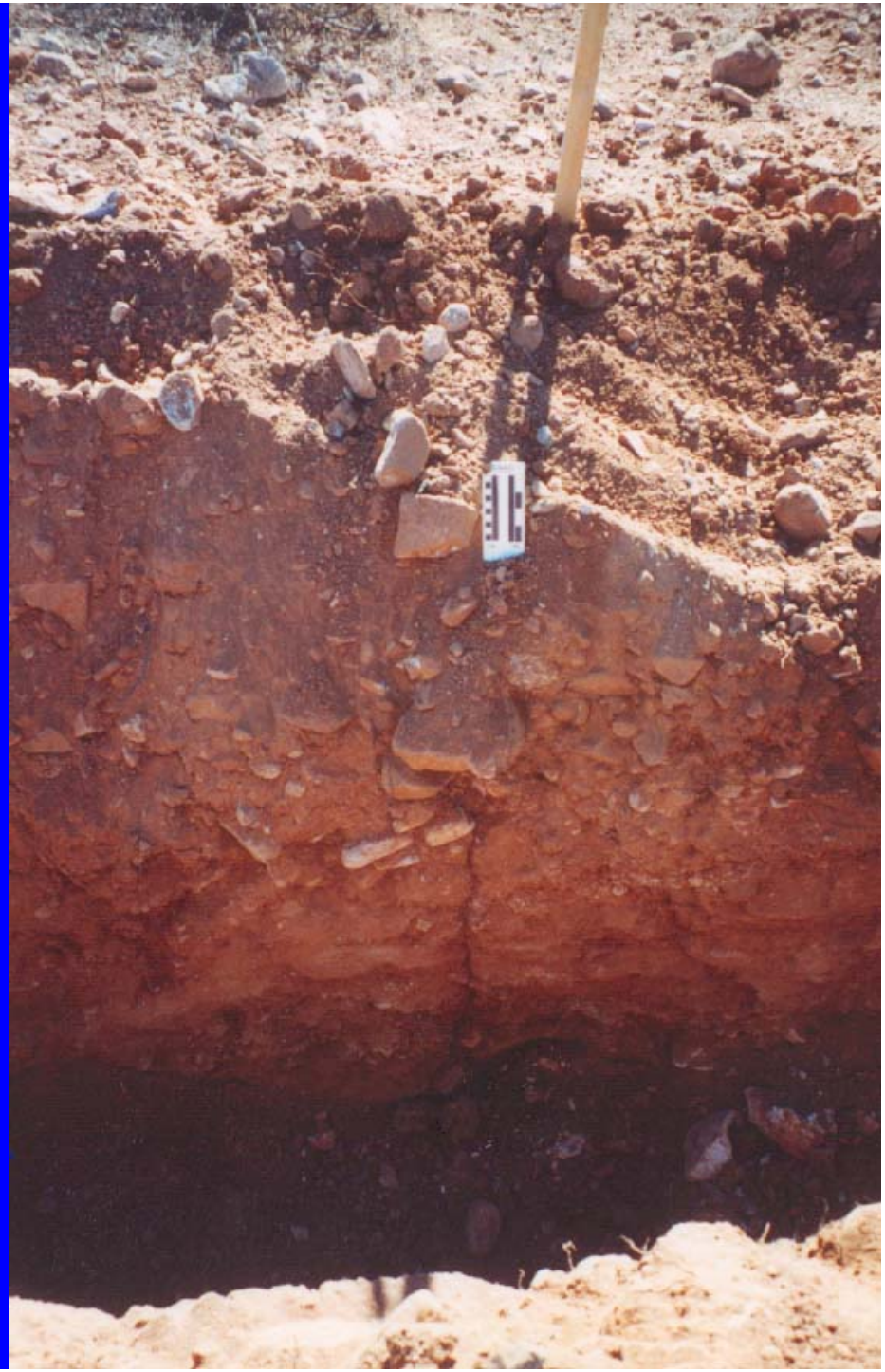
Shallow seismic refraction (using attenuation and time delay) can be used to trace connected vertically oriented cracking features associated with subsidence or other ground movement

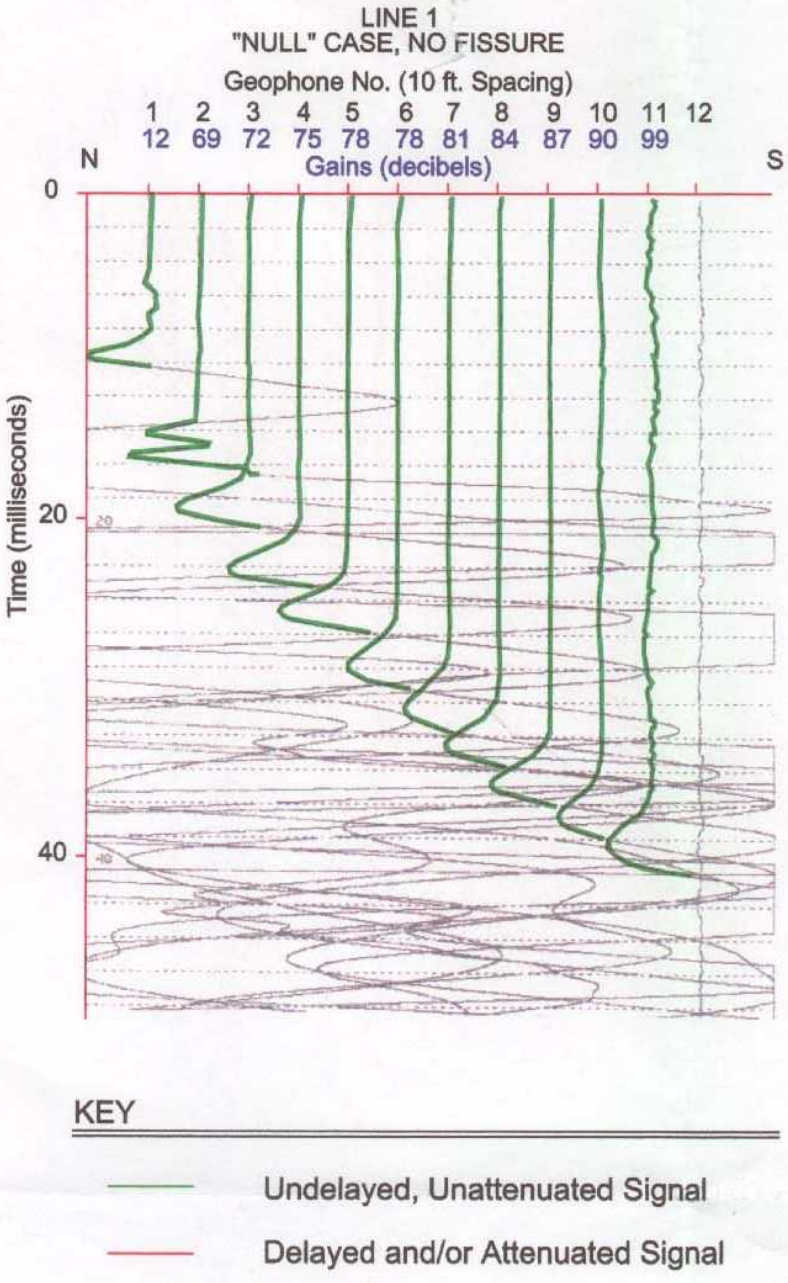
Following search pattern using seismic refraction, features not visible at the surface can be identified and located

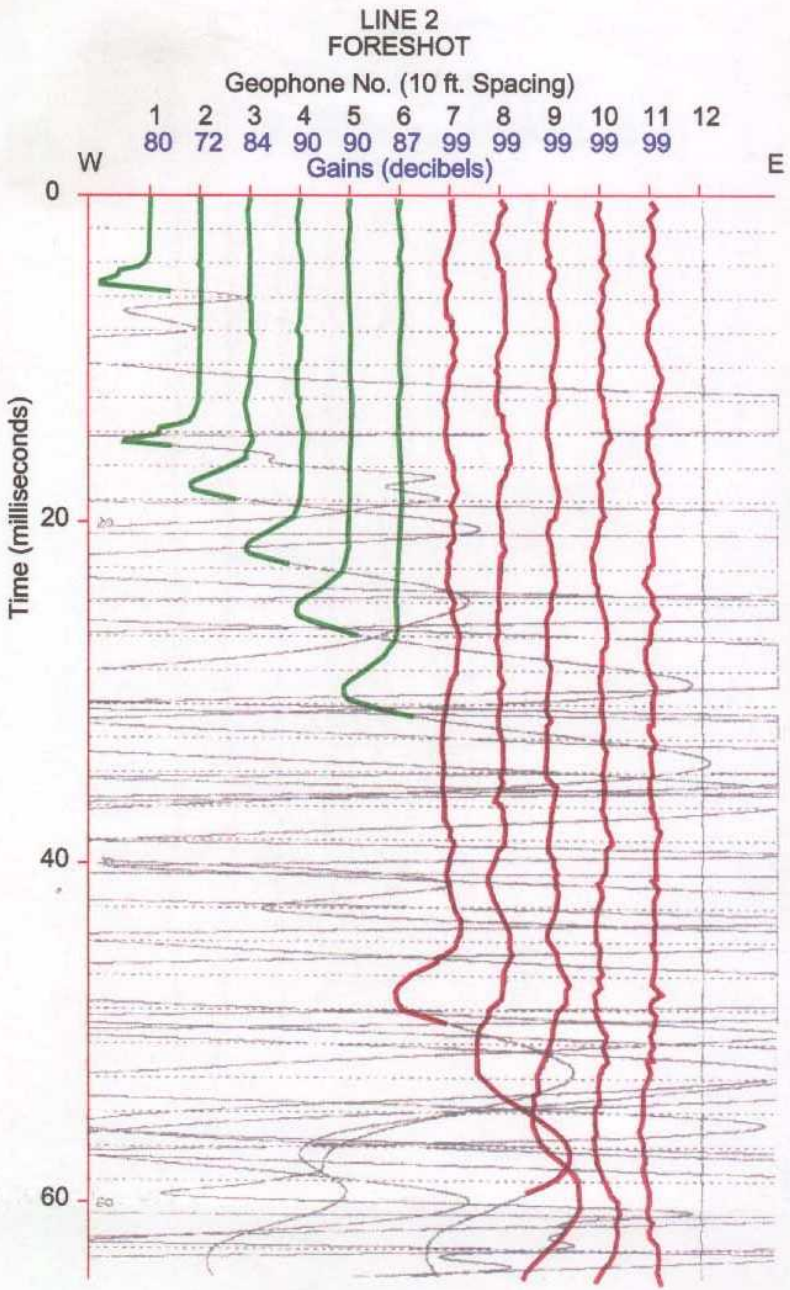
Further investigation, typically trenching, can provide confirmation of presence or absence of crack features

Example of earth fissure location identified by seismic refraction and then verified by trenching

(not all calls are that close)



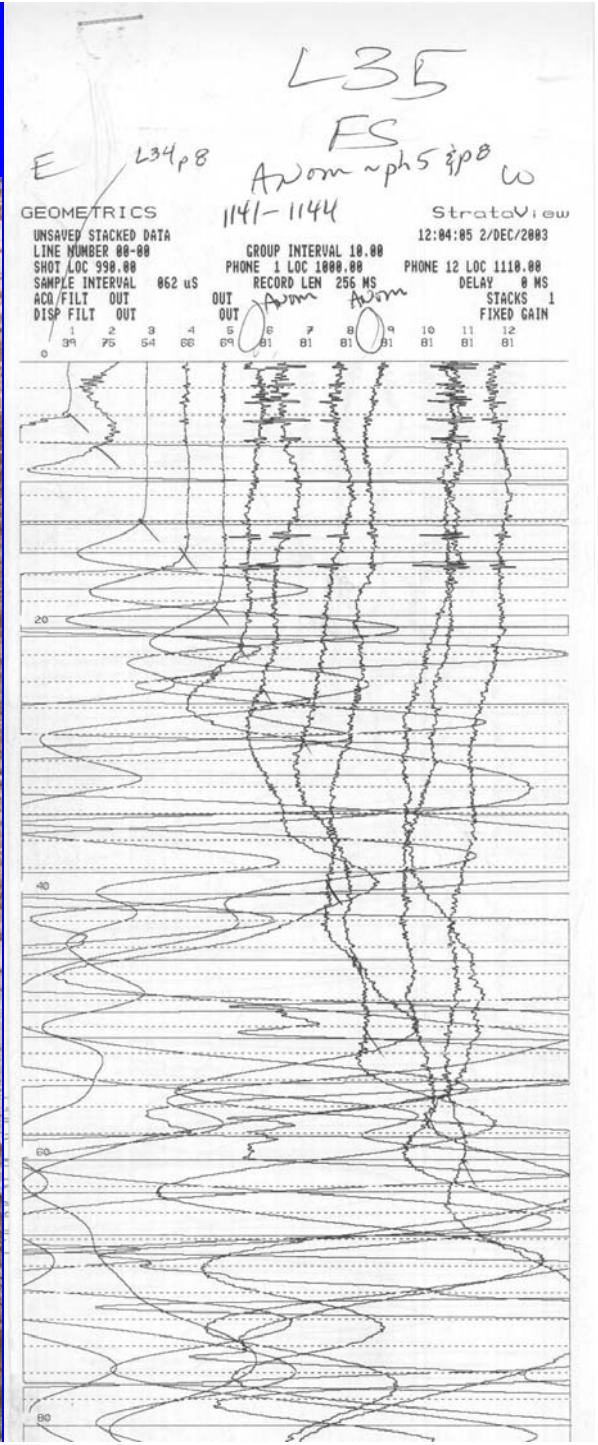

LINE 1
"NULL" CASE, NO FISSURE
Geophone No. (10 ft. Spacing)
1 2 3 4 5 6 7 8 9 10 11 12
12 69 72 75 78 78 81 84 87 90 99
Gains (decibels)
N
S
0
20
40
Time (milliseconds)
KEY
Undelayed, Unattenuated Signal
Delayed and/or Attenuated Signal


LINE 2
FORESHOT
Geophone No. (10 ft. Spacing)
1 2 3 4 5 6 7 8 9 10 11 12
80 72 84 90 90 87 99 99 99 99 99
Gains (decibels)
W
E
0
20
40
60
Time (milliseconds)

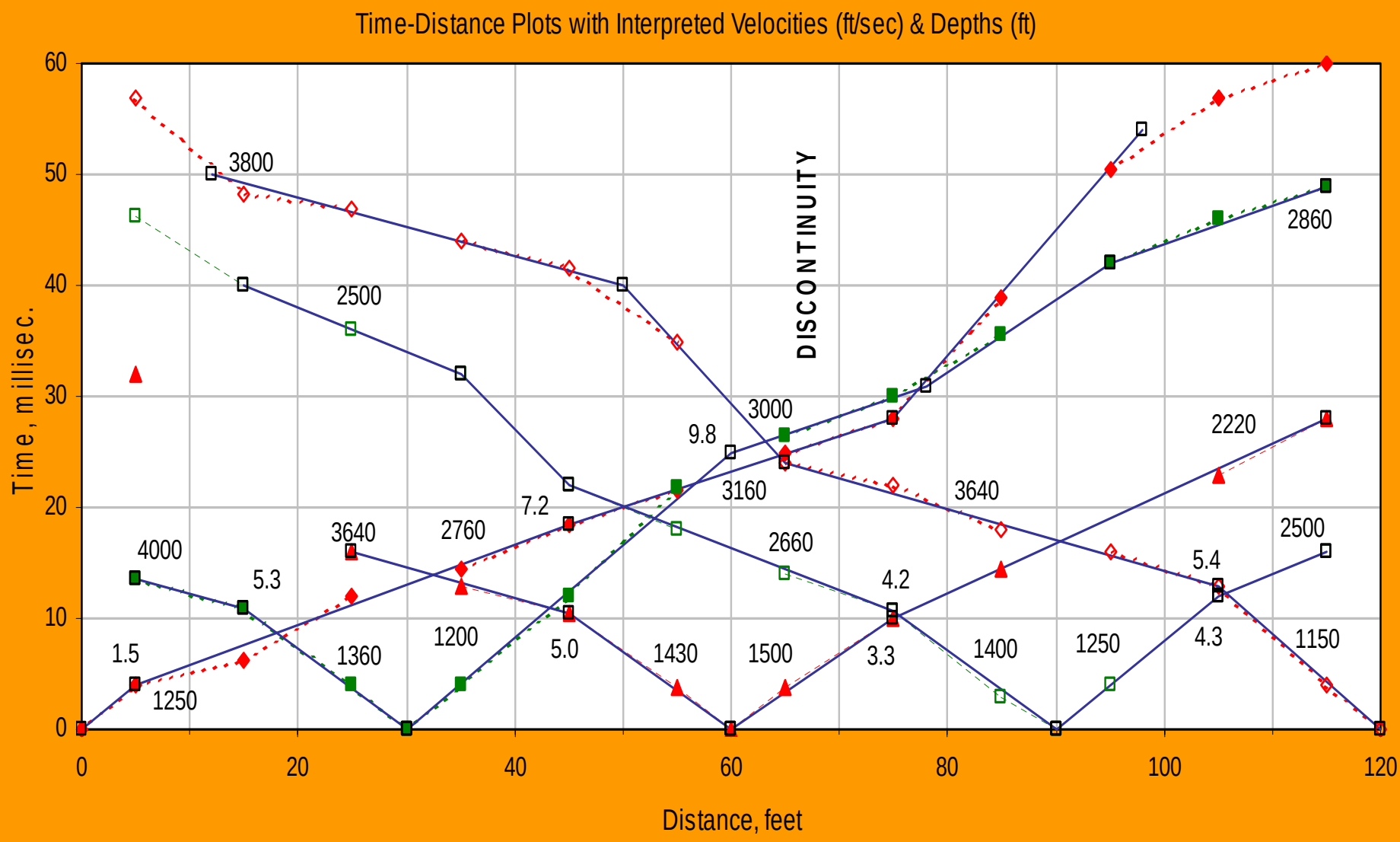
Seismic refraction method can identify crack features with small aperture as well as larger aperture

Observation and investigation of crack features found in this manner indicates that crack ‘connectivity’ is needed to block transmission of the seismic signal efficiently

Another example of seismic traces and actual crack feature



Seismic refraction example time-history data & results



Where ground distress is more generalized than a discrete crack, seismic velocities for that zone tend to be lower relative to undisturbed areas

- collapse areas
- landslide or potential landslide areas

- ReMi strengths - seismic refraction weaknesses

- Seismic refraction strengths - ReMi weaknesses

SEISMIC GEOPHYSICS IS (AND IS READY TO BE) A STANDARD GEOTECHNICAL TOOL